DOCUMENT RESUME

ED 467 135 EC 309 091

AUTHOR	Zadina, Janet N.
TITLE	Structural Neuroimaging Studies of Dyslexia: Issues of Validity and Value.
PUB DATE	2002-04-00
NOTE	26p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 1-5, 2002).
PUB TYPE	Reports - Evaluative (142) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	Classification; *Clinical Diagnosis; Definitions; *Disability Identification; *Dyslexia; Elementary Secondary Education; Interdisciplinary Approach; *Neurological Impairments; Neurological Organization; *Research Problems; *Symptoms (Individual Disorders); Validity
IDENTIFIERS	*Magnetic Resonance Imaging; *Neuroimaging

ABSTRACT

This paper argues that because estimates of the number of people with developmental dyslexia range from 3% to 20% of the population, it is imperative that educators be knowledgeable about dyslexia, including being up-to-date on the neuroanatomical dyslexia research. It then reviews neuroanatomical research, including findings from seminal research and neuroimaging research. Research inconsistencies are then discussed, including three important ways the research is compromised. First, it is argued, the new neuroimaging methodology has several weaknesses that negatively affect validity. Secondly, the nature of the disorder itself creates issues of validity. Finally, educators' practices can affect the validity at the very basis of the research study-the study sample. Problems with the discrepancy definitions and the deficiency definition of dyslexia are addressed, along with additional definitional issues. The need for further studies to screen for a specific subtype of dyslexia and correlate that subtype with brain anatomy is stressed, and a recursive model is proposed for the interrelationship of educators, neuroscientists, and medical practitioners. It is emphasized that through this recursive process, students with demonstrated or potential reading disabilities can be identified earlier and given more specific, individualized and appropriate teaching and learning strategies. (Contains 50 references.) (CR)

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ED 467 135

Structural Neuroimaging Studies of Dyslexia:

Issues of Validity and Value

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Abstract

Estimates of the number of people with developmental dyslexia range from 3% to 20% of the population. Given the pervasiveness of this disorder, it is imperative that educators be knowledgeable about dyslexia, including being up-to-date on the neuroanatomical dyslexia research.

The neurobiological substrates of dyslexia have been the focus of research since Galaburda's seminal studies on brain asymmetry in the PT. Underlying Galburda's hypothesis is the theory that asymmetry and functional lateralization are related. His postmortem analysis of the brains of four dyslexic patients found that the brains of dyslexics were symmetrical as opposed to the asymmetrical pattern found in most brains. This suggested the possibility that during later stages of brain development, injury to the brain restructured the cortical architecture of asymmetry and cerebral dominance, raising the question of whether anatomical differences are related to reading difficulties.

While Galaburda's postmortem studies provided the first opportunity to actually see anomalies in the dyslexic brain, magnetic resonance imaging (MRI) now provides a clear way to see the human brain *in vivo*, in living humans, and to examine brain anatomy and function in healthy individuals and in individuals with neurodevelopmental disorders like dyslexia. The question of whether dyslexic brains have anomalous anatomy remains unresolved.

While researchers continue to investigate hypothesized anatomical differences in the brains of dyslexics, the validity of this research effort is compromised in three important ways and may underlie some of the inconsistencies across studies. First, the new neuroimaging methodology has several weaknesses that negatively impact validity. Secondly, the nature of the disorder itself creates issues of validity. Finally, educators' practices can affect the validity at the very basis of the research study – the study sample. Therefore, the role of educator in referrals is imbued with responsibility. Additionally, educators add value to scientific research throughout an interactive and interdisciplinary recursive process in which the role of educators is integral and critical.

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Estimates of the number of people with developmental dyslexia range from 3% to 20% of the population (Council on Scientific Affairs, 1989; Riccio & Hynd, 1996; Rumsey et al., 1997; Padget, 2000; Futterweit, 1999). Given the pervasiveness of this disorder, it is imperative that educators be knowledgeable about dyslexia, including being up-to-date on the neuroanatomical dyslexia research. A better understanding of brain anatomy and function in dyslexia may lead to earlier identification of children at risk and to targeted intervention strategies.

Neuroanatomical Research

It has been well established that the brain is lateralized, i.e., the two hemispheres of the brain serve different functions. Language functions have long been associated with the left hemisphere in most right-handed people, particularly in Broca's area and Wernicke's area. Studies have demonstrated that portions of Wernicke's area, the planum temporale (PT), are larger in the left cerebral hemisphere in most right-handers (Foundas, Leonard, & Heilman, 1995; Foundas, Hong, Leonard, & Heilman, 1998), creating anatomical asymmetry. This means that the critical language regions are usually larger in the left hemisphere language area than in the homologous area in the right hemisphere (Foundas, Leonard, Gilmore, Fennell, & Heilman, 1994; Foundas, Lane, Corey, Hurley, & Heilman, 2001). For over 100 years, researchers have speculated that the larger brain region in the left hemisphere was more "dominant" for language functioning; but there is still relatively little direct evidence that there is a relationship between anatomy and language dominance (Foundas et al., 1994). Researchers speculate that anomalies of this asymmetry may be related to disruption in the development of this area of the brain and, thus, to language processing disorders, including dyslexia (Foundas, Leonard, & Hanna-Pladdy, 2002).

Seminal Research

The neurobiological substrates of dyslexia have been the focus of research since Galaburda's seminal studies on brain asymmetry in the PT (Galaburda et al., 1985). Underlying Galburda's hypothesis is the theory that asymmetry and functional lateralization are related (Habib, Robichon, Levrier, Khalil, & Salamon, 1995). His postmortem analysis of the brains of four dyslexic patients found that the brains of dyslexics were symmetrical as opposed to the asymmetrical pattern found in most brains (Galaburda & Kemper, 1979). This suggested the possibility that during later stages of brain development, injury to the brain restructured the cortical architecture of asymmetry and cerebral dominance (Filipek, 1995), raising the question of whether anatomical differences are related to reading difficulties. Galaburda hypothesized: "that more symmetry or otherwise an alteration in the standard pattern of asymmetry of the planum and related parts of the brain is statistically linked to, and can possibly be a causative factor..." in dyslexia (1991, p. 123).

After Galaburda's landmark postmortem studies created further investigation into asymmetry, Norman Geschwind began investigating the connection between language disability, left-handedness, and autoimmune disorders. This led to a landmark theory: the *testosterone theory*, also known as the *Geschwind/Galaburda hypothesis*, which states that hemispheric dominance is a result of influences on fetal brain development, particularly that of testosterone or immune factors (Schachter, 1993).

While Galaburda's postmortem studies provided the first opportunity to actually see anomalies in the dyslexic brain, magnetic resonance imaging (MRI) now provides a clear way to see the human brain *in vivo*, in living humans, and to examine brain anatomy and function in healthy individuals and in individuals with neurodevelopmental disorders

like dyslexia. As Filipek states: "...the required technologic foundations are now in place to appropriately approach developmental dyslexia within the realms of cognitive neuroscience" (Filipek, 1995, p. S68), as well as neurology and even molecular biology. As a result, researchers have been able to examine the brain in greater detail than ever before. Some researchers are using functional MRI (fMRI) and positron emission tomography (PET) to study the *functional* organization of the brain while others use postmortem and MRI to examine the *structure*. Resolution of the question of whether the brains of dyslexics have anomalous asymmetry appears to be an important area of research at this time. As Rosen states:

> Understanding the mechanisms involved in the development of symmetrical and asymmetrical brains "could lead to a greater understanding of the ways in which the development of the brain of a dyslexic differs from that of normal readers" (1993, p. 103).

Neuroimaging Research

As the new technology of MRI developed, there were few early studies. Studies prior to 1989 are well-reviewed by Hynd & Semrud-Clikeman (1989). Eight anatomical neuroimaging studies, conducted between 1989 and 1993, were reviewed by Filipek in 1995. The state of the research in 1994 is characterized by Filipek (1995) as being inconsistent, with results only suggestive, rather than indicative, of anatomical characteristics of dyslexia. The research is described as confounded by "effects of sex, handedness, socioeconomic status, psychiatric codiagnoses, intellectual ability, or educational setting" (Filipek, 1995, p. S63). These early studies focused primarily on the PT.

Several reviews of neuroanatomical research on dyslexia have been written since Filipek's 1995 review (Beaton, 1997; Kender & Kender, 1998; Robichon & Habib, 1998; Habib, 2000; Eckert & Leonard, 2000), but the question of whether dyslexic brains have anomalous anatomy remains unresolved. Questions of asymmetry of the planum temporale, the most studied area, still remain. Furthermore, it has not been resolved whether anomalies of asymmetry in other nearby areas, such as the PP, exist. Measurement techniques have become more refined and equipment has become more widely available. In attempts to create consistency, researchers have attempted to describe the boundaries of the ROIs more clearly and some of the more recent studies include nearby structures, such as Heschl's Gyrus (HG) and the posterior ascending ramus (PAR). Eckert and Leonard (2000) conclude in their review of planum temporale studies that if the discrepancy definition is not used, a measure of PT asymmetry can predict reading differences.

Future Direction

Leonard's discovery that "different neural measurements contribute cumulatively to the risk of a phonological deficit... suggests that anatomy may have a future in subdividing complex behavioral disorders into more homogeneous groupings" (Leonard et al., 2001, p. 171-2). Studies of the planum temporale and adjoining areas, however, would benefit from standardized definitions of these areas. Hienmenz & Hynd (2000) suggest that including the sulcal patterns may improve knowledge of brain structure and function. New equipment and the ability to make thinner slices should help with this identification. Future studies should attempt to screen for a specific subtype of dyslexia and correlate that subtype with brain anatomy. Stringent screening resulting in more homogenous groups may help resolve the questions of asymmetry. It may be that studies

of the PT will enable research to focus on a specific subset with a particular anomaly or that the set of anomalies could be used to make a distinction between dyslexics and controls (Kelley, 1993). Functional studies with functional MRI and PET could be used as part of the screening process and correlation between functional activation-deactivation patterns and anatomical anomalies. In order to focus on a clinical subtype, samples must be more homogenous.

Dalby, et al. offer a caveat addressing all of this research, however, when they state: "What looks like constitutional, inherited differences in the structure of the brain may still be consequences of differences in reading habits rather than causes of the difficulties. Rather than a reflection of the number of neurons, the modest differences in size may reflect the number of synapses or the degree of myelinization or some other neurological correlate to acquired skills" (Dalby, Elbro, & Stodkilde-Jorgensen, 1998, p. 66). Furthermore, they bring this research back to the domain of educational researchers when they state "The implications for education are not at all clear as long as the above questions are still unanswered (P. 67).

The underlying issue in all of these studies is that the field of imaging neuroanatomy in dyslexics is in its infancy. It is exhibiting growing pains as it experiments with different techniques and technology. In spite of the shortcomings in this new area of specialization, it seems clear that anatomical studies are contributing to our body of knowledge and are an important component, along with behavioral and functional information, in understanding the ongoing mysteries of dyslexia. However, quality research depends upon well-defined subjects and controls. Educators' contribution is critical to this research process.

Issues of Validity

While researchers continue to investigate hypothesized anatomical differences in the brains of dyslexics, the validity of this research effort is compromised in three important ways and may underlie some of the inconsistencies across studies, as discussed in the next three sections of this paper. First, the new neuroimaging methodology has several weaknesses that negatively impact validity. Secondly, the nature of the disorder itself creates issues of validity. Finally, educators' practices can affect the validity at the very basis of the research study – the study sample.

Research Methodology Validity Issues

While researchers attempted to control for some of the confounds mentioned above, other factors were not controlled for. This research continues to be plagued with conflicting definitions and screening procedures and confounds of handedness, gender, age, and many others. In addition, since some studies, both functional field and anatomical, show correlations with genetics, SES, prenatal distress, delivery complications, autoimmune diseases in the mother, ADHD, IQ, level of education, body size, brain size, and history of developmental language disorder, studies must be carefully designed and consistent screening measures put in place to address these.

In addition to confounds in the research sample, methodological discrepancies abound and compromise the validity. This new field is in its infancy, and as with other new domains, there is an attendant lack of standardization. Studies on the neuroanatomy of dyslexia differ in their sampling population, measurement techniques, definition of regions of interest (ROI), and their conclusions. This lack of consensus on many levels creates several problems that must be considered when evaluating the literature. Regarding this research, Filipek concluded that "Direct comparisons cannot be made at

present between the published studies of the plana temporale in dyslexia" because of confounds and measurement concerns (1995,p.S67).

Many studies have suggested that there are subtypes of dyslexia and this further complicates the research. If one subtype has one etiology and another subtype a different one, then the research on neuroanatomy is bound to have conflicts. Another reason why the findings in dyslexia research are so inconsistent is that some studies use compensated dyslexics and others use noncompensated, or, more often, a mixture of each, and ignore this as a possible variable.

The fact that these studies show conflicting findings is not surprising, as all of these discrepancies affect the validity of the research. Factors outside the study design, however, also negatively impact validity.

Inherent Validity Issues

The inherent nature of dyslexia creates several problems for researchers. Both educators and clinicians have noticed that certain factors seem to be correlated with dyslexia. This association creates confounds in the research. Are factors other than dyslexia itself correlating to anomalous anatomy? Furthermore, perhaps these factors are actually correlated to subtypes within the dyslexia population and this creates conflicting findings in the research. All of the following have been investigated as somehow associated with dyslexia, and thus, can act as confounds, affecting validity of the research. (1) Gender: It has been widely believed that there are many more male dyslexics than female. Research results are conflicting. (2) Non-right-handedness (NRH) This trait has commonly been associated with dyslexia since Geschwind and Galaburda's early research noting the correlation. (3) Immune Disorders: Galaburda's seminal research implicated the immune system and research continues to suspect that it may be a

factor (DeFries, Olson, Pennington, & Smith, 1991; Rosen, Sherman & Galaburda, 1993). The relationship remains unresolved. (4) Additional, less-studied correlations: Hugdahl found "hand posture when writing, sightedness, stuttering and complications during pregnancy and/or at delivery...have all been suggested to correlate with laterality and/or dyslexia" (Hugdahl, 1993, p. 140). Difficulty with spatial relationships, directionality, left-right discrimination, and time orientation occur in dyslexics (Johnson, 1995). Low socioeconomic status, large family size, and urban areas are also correlated (Council on Scientific Affairs, 1989). A right-ear advantage has also been noted (Futterweit, 1999). Over time the following have also been suspected as confounds in the research: age, family history, brain size, body size, educational achievement, IQ, and the presence of other developmental or psychological disorders – particularly attention deficit disorder (ADD), attention deficit hyperactivity disorder (ADHD), and developmental language disorder in the subject or in the family.

Educational Practices Validity Issues

Typically, a subject is screened into a dyslexia research study because an educational practitioner has previously defined the subject as a dyslexic. However, certain factors in the process of defining someone as dyslexic compromise the validity. First, and most obviously, arises the question of *how* to define dyslexia. Different definitions may lead to different research cohorts. Inherent within this issue is the question of whether subtypes of dyslexia may exist. If so, then research cohorts may be composed of more than one subtype. Finally, the question of *who* defines dyslexia and their perceptions affect who is labeled and then enrolled into dyslexia research. Inconsistency in the overall process of defining someone as dyslexic compromises the

validity of the dyslexia research from the beginning, as it is important to have homogenous groups in a study sample.

Definitions

Since 1917 the definition of the term *dyslexia* has been a source of confusion (Roberts & Mather, 1997; Cibils, 1996). Definitions vary from state to state and affect diagnosis of students and their eligibility for treatment (Shaw, Cullen, McGuire, & Brinckerhoff, 1995, p. 586). Public Law 94-142, the Education of All Handicapped Children Act, includes dyslexia but does not give specific criteria (Council on Scientific Affairs, 1989). Since researchers often screen subjects into dyslexia studies on the basis of an earlier diagnosis of dyslexia, this variation in definition affects the scientific research as well. Two popular operational definitions are widely used and are known as the *discrepancy definition* and the *deficiency definition.*

Discrepancy definition

The most common screening definition of a dyslexic is defined as: "an individual with a significant discrepancy between his or her IQ and reading scores, so that the reading score is significantly lower than would be predicted by the IQ" (Siegel, 1998, p. 123). Inherent in this definition is the assumption of normal intelligence and the absence of other factors contributing to reading delay, such as uncorrected vision or hearing problems or neurological, emotional, or behavioral problems (Riccio et al., 1996; DeFries et al., 1991). It is "the failure to acquire age-appropriate reading skills despite adequate intelligence and opportunity to learn" (Harm & Seidenberg, 1999, p. 491). Some have used a looser screening definition, based on a discrepancy between subjects' difficulty in reading and spelling and their ability to perform normally in other areas (DeFries et al.,

1991). The discrepancy definition is widely used in schools because it is easy and can prevent liability issues (Cordoni, 1995).

Deficiency definition

The second common screening definition defines someone as dyslexic if they are referred by a teacher or school psychologist due to poor performance in school or on tests or if they are referred to a reading therapist (DeFries et al., 1991). Again, there are problems with this definition. Reading ability is not a discrete task but rather a continuum, so boundaries are unclear. A categorical definition precludes information regarding variation (DeFries et al., 1991). Furthermore, subjectivity can enter into this definition and students who are not failing in school but who have dyslexia may not get services. Some use an estimated grade level of reading ability, which makes it difficult to compare across studies. Definitions may be confounded by Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD) and this can lead to conflicting results in research studies (Wimmer, Mayringer, & Raberger, 1999). While these definitions have been widely used in education and scientific research, as neurological studies have begun, additional definitions are being described.

Additional definitional issues

The definition provided by the Research Group on Developmental Dyslexia of the World Federation of Neurology is now the most common: "A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin"(Shaywitz et al., 1991, p. 29).

Regardless of the definition used, there are additional problems inherent in the act of defining someone as dyslexic. First of all, there is ongoing debate over whether to

define dyslexia as a continuous or discontinuous state. A definition of dyslexia as actually just one end of the normal distribution is under debate as a result of neurological studies showing that dyslexics have features either not active or not existent in the normal population (Duane & Gray, 1991). However, in 2000, a study of white matter concludes that it supports the definition of poor reading as one end of the reading continuum (Klingberg et al., 2000). This remains unresolved.

An additional complication of defining someone as dyslexic is that the professional background of the assessor and his or her concept of dyslexia can affect the diagnosis. Most of those diagnosed are in a school setting and diagnosed by psychologists rather than physicians: therefore, family and medical backgrounds are often not taken and developmental disorders are often not diagnosed as early as could be possible. "Gender, race and other demographic and cultural variables need careful attention, since they may operate to confuse the definition of cases" (Wood, Felton, Flowers, & & Naylor, 1991) (p. 21). In addition, confounding symptoms of ADHD must be addressed (Wood et al., 1991). DeFries, Gillis, and Wadsworth provide a valuable discussion of how the problem of defining samples as dyslexic can affect research (DeFries & Gillis, 1993).

Disagreement about the definition is a serious problem in the field. One of the effects is to confuse the issue of how many people are dyslexic. Galaburda's (1985) estimates 5-15%. At the end of the 80's, the most common estimate was 3% - 6% of school-aged children (Council on Scientific Affairs, 1989). Riccio and Hynd (1996) put the estimate at 2-8%, while Futterweit (1999) cites an estimate of 3%-10%.

As a result of conflicting bases for screening dyslexics, there is a negative impact on referral and treatment. Furthermore, "the dearth of consistent criteria, lack of

diagnostic rigor and conceptual vagueness of the LD field undermine public confidence in it" (Shaw et al., 1995, p. 586). This conflict also reduces generalizability in research. Indeed, in order to perform quality research, it is essential to have "a precise definition of a homogeneous phenotype" (Leonard et al., 2001, p. 149). Lubs et al. concur by saying that "widely different study samples (all called 'dyslexia')" cannot be compared (Lubs et al., 1991). In 1996, Lyon noted that the lack of a precise definition and a theoretically based classification system is "probably the most significant and persistent problem in the field" (Lyon, 1996, p. 59) and others concur (Shaywitz et al., 1991). Along these lines, some researchers have begun to create classifications of subtypes of dyslexia.

Subtypes of Dyslexia

Early studies may be conflicting because the subjects had heterogeneous cognitive impairments and their cognitive abilities may have varied neurodevelopmentally or genetically (Leonard et al., 2001). The difficulty of selecting homogeneous groups for study coupled with the movement away from attributing dyslexia to a single cause has led researchers to describe subtypes (Njiokiktjien, 1993). Njiokiktjien states: "It is unfeasible to speak of *the* substrate, *the* pathogenesis, or *the* etiology" (Njiokiktjien, 1993, p. 206). In fact, he states that "We do not consider dyslexia one nosological entity, and this is why we prefer to speak of dyslexias or, in other words, of the various subtypes of dyslexia caused by a variety of neuropsychological defects" (p. 216).

As early as 1953, Gjessing differentiated orthographic processing deficiencies from phonological processing deficiencies and many researchers have continued to analyze dyslexia as a *dual model*. Early on, researchers were classifying dyslexics as either auditory or visual (Council on Scientific Affairs, 1989).

Numerous subtypes and classification systems have been proposed (Van Strien, Stolk, & Zuiker, 1995; Njiokiktjien, 1993; Harm et al., 1999, Roberts et al., 1997; Boder, 1971; DeFries et al., 1991; Lubs et al., 1991; Hugdahl, 1993; Shaywitz, Fletcher, & Shaywitz, 1995; Cibils, 1996; Padget, 2000; Seymour & Evans, 1999); however, there seems to be almost as much inconsistency in subtypes as in the definition, and certainly a good deal of overlap. "As Siegel and Metsala (1992) stated in their summary of this literature: It appears that the study of subtypes has been plagued by serious definitional issues and that there does not appear to be any evidence of reliable subtypes within the reading disabled population" (Doris, 1998, p. 18). This lack of standardization of definition of clinical subtypes complicates the referral process for educators, which, in turn, can impact the homogeneity of research samples. To improve the validity of scientific research on dyslexia, it is imperative that educators carefully define and subtype dyslexia.

Issues of Value: A Recursive Relationship

While scientific research brings value to educators responsible for designing and/or implementing intervention strategies, educators bring value to scientific research. As discussed above, educators' decisions when identifing someone as dyslexic may have implications for the results obtained in scientific research. Therefore, the role of educator in referrals is imbued with responsibility. Additionally, educators add value to scientific research throughout an interactive and interdisciplinary recursive process in which the role of educators is integral and critical.

I propose a recursive model for the interrelationship of educators, neuroscientists, and medical practitioners. For someone exhibiting symptoms of dyslexia, both educational and biomedical practitioners should be closely involved in creating

diagnostic tools, analyzing symptoms, and monitoring progress. When the educational practitioner diagnoses a reading disability, he or she can begin to ascertain the specific individual symptoms being presented and start appropriate treatments for observed symptoms. At the same time, the educational practitioner refers the learner to a medical practitioner so that functional studies with functional MRI and PET could be used as part of the screening process. The medical practitioner begins looking at the neurobiological substrates to investigate anatomical, functional, and genetic indicators to define a clinical subtype and to correlate subtypes or clinical features with brain anatomy. Correlations between functional activation-deactivation patterns and anatomical anomalies can be investigated. The neuroscientist or medical practitioner then gives interim feedback to the educational practitioner who provides intervention, monitors symptoms, and gives feedback to the neuroscientist/medical practitioner. This recursive process continues.

Physicians are important members of the dyslexia cross-disciplinary team. They can offer early screening and referral, help interpret test results, offer guidance on current proposed treatments, and provide families with support and suggested readings (Council on Scientific Affairs, 1989). As the educational researcher gets feedback from the medical community, he or she can devise and test appropriate educational practices for specific subtypes in the best laboratory possible – the classroom - and give feedback to the biomedical field. At the same time, the medical and neuroscientist researchers study the many facets of dyslexia, creating a larger database, defining subtypes, and searching for ways to detect, and eventually address, the ultimate cause(s) of dyslexia. This information comes back to the educational researcher who tests and refines appropriate techniques for addressing the symptoms. Through this recursive process, students with

demonstrated or potential reading disability can be identified earlier and given more specific, individualized, and appropriate teaching and learning strategies.

Conclusion

The lack of a definitive test for dyslexia has led to the selection of heterogeneous study samples with conflicting results and we return to the original dilemma. If dyslexia cannot be defined in such a way to select homogeneous subjects to isolate the myriad of interacting factors, then how can data be definitive? Researchers need to establish a database of functional and anatomical data and to develop a detailed classification system with neurological, genetic, developmental and educational components. Eckert et al. (2000) pointed out that the heterogeneity among dyslexic subjects "is consistent with the idea that there could be a variety of neurobiological paths leading to the diagnosis of dyslexia. Taken together, it is possible that a set of neural risk factors could discriminate between control and dyslexic populations" (p. 205). Studies using MRI's can play an important role in looking at structure and and function (Caviness, Jr., Filipek, & Kennedy, 1993) and data about the brains of good readers is needed for comparison (Duane et al., 1991; Filipek & Kennedy, 1991).

But this research cannot achieve optimal validity unless educators are knowledgeable about the research and take an active role. Educators need to work toward development of standardized measures of dyslexia on a national basis and consistency of diagnosis of dyslexia. Subtypes of dyslexia and classification systems should be identified, standardized, and utilized. No longer should students be diagnosed as "dyslexic," but rather they should be diagnosed has having a specific clinical subtype of a neurodevelopmental disorder with a specific categorical diagnosis and itemized symptoms. An anatomical, functional, genetic, and educational multidisciplinary

approach is critical. As educators we can no longer be satisfied with generic diagnoses and generic treatment options. In order to achieve these changes, however, educators must become activists for reform and become involved in all aspects of dyslexia, including diagnosis, intervention, and research.

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